Exhibit K

To

Joint Claim Chart

File History Report

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60/333,921

Method and system for handling interlaced video with the H.26L encoding standard

Transaction History

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12/4/2001	IFW Scan & PACR Auto Security Review
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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TITLE OF THE INVENTION (500 characters max)

"Method and System for Handling Interlaced Video with the H.26L Encoding Standard"

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[ ] A check or money order is enclosed to cover the filing fees
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REGISTRATION NO. (if appropriate) 40,326
Docket Number: 80113.234

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Docket Number	80113.234

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ABSTRACT

The H.26L encoding standard improves on the previously MPEG standards by requiring substantially less bandwidth to carry video of comparable quality. However, the H.26L standard does not at present contain any provisions for handling interlaced video. Consequently, interlaced video can be handled under the H.26L encoding standard by dividing each macroblock into blocks and then dividing each block into one of two fields within the frame. Alternatively, interlaced video can be handled under the H.26L encoding standard by dividing each macroblock into two fields and then dividing the fields in each macroblock into blocks. Motion compensated transformations are then performed on each field/block division effectively doubling the number of resulting motion vectors generated as compared to non-interlaced video. Using these methods, the H.26L encoding standard can be made to handle interlaced video.

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TITLE OF THE INVENTION

Method and System for Handling Interlaced Video with the H.26L Encoding Standard

FIELD OF THE INVENTION

[0001] The present invention relates to the field of transmitting video signals. More particularly, the present invention relates the field of transmitting encoded video signals using the H.26L encoding standard of the International Telecommunications Union. Specifically, the present invention supplies a means and method of handling interlaced video signals while employing the H.26L encoding standard to compress the video for transmission.

BACKGROUND OF THE INVENTION

[0002] The transmission of video signals by cable, satellite or over-the-air broadcasting provides a tremendous amount of video programming for such purposes as entertainment and education. As an ever-increasing volume of programming becomes available and consumers desire improved picture and sound quality, there is a constant effort to improve the technology by which video programming is transmitted to increase both the volume and quality of the transmitted programming.

[0003] One effect of this drive for improvement is the current shift from analog to digital video broadcasting. Traditional over-the-air video broadcasting has used analog signals. Analog signals are easier to produce and broadcast, but carry less data than digital signals. Thus, with digital video broadcasting both the quantity and quality of the programming transmitted can be improved. As a result, first cable and satellite systems, and now over-the-air broadcasting systems, are moving toward use of a digital video signal.

[0004] Both analog and digital video can be classified as either interlaced or non-interlaced. In non-interlaced or progressive-scanning video all the horizontal lines in a frame are displayed, one after the other, in one pass from top to bottom before the next frame appears. Most personal computers use progressive scan video. In contrast, interlaced video divides each frame into two interlaced fields. Each field contains every other horizontal line in the frame. The two fields are displayed in two subsequent passes. The first pass displays every other horizontal line of the frame, i.e., the first field. The second pass adds the

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intermediate lines of the frame, i.e., the second field. Thus, a television set or video monitor displays the first field of alternating lines over the entire screen, and then displays the second field to fill in the alternating gaps left by the first field. Over-the-air broadcast television has traditionally employed interlaced video.

[0005] Under the NTSC standard for broadcast television used in United States, each broadcast video frame is displayed for approximately 1/30th of a second and contains two interlaced fields. Each field is displayed for approximately 1/60th of a second each. Under the PAL and SECAM standards used in Europe and other parts of the world, video frames display at 1/25 of a second and contain two interlaced fields displayed for 1/50th of a second each. The field that contains the topmost scan line in the frame is called the upper field, and the other field is called the lower field.

[0006] Television signals are interlaced because of the nature of early television sets and the nature of human vision. When a series of frames are presented, the frame rate (the time interval between frames) has to be high enough to achieve persistence of vision, i.e., a continuous image without noticeable flicker. The United States uses a 60Hz power cycle, but early television sets were only able to display 30 frames per second (fps). By interlacing two fields at 30 fps, an effective display rate of 60 fps was achieved. This solved the problem of low bandwidth and was high enough to provide adequate persistence of vision. This early solution has made interlacing at 30 fps the US standard. Now that technology can produce higher frames rates, interlacing is still utilized due to its ability to provide persistence of vision at lower bandwidths than progressive scanning.

[0007] Whether or not interlaced, video signals are also frequently compressed or encoded to conserve bandwidth. The general idea behind encoding is to remove data from the video signal that is "non-essential." The decreased amount of data then requires less bandwidth for broadcast or transmission. When the signal is received, the video signal must be decompressed or decoded. In this process, the transmitted video data is processed to generate approximation data that is substituted to replace the "non-essential" data removed during encoding.

[0008] The Motion Pictures Expert Group (MPEG) has standardized a number of encoding techniques for video that are currently very popular. These are known as MPEG-1,

MPEG-2 and MPEG-4. These encoding standards can handle both interlaced and non-interlaced video. In particular, MPEG-2 has been used effectively now for several years to deliver interlaced video over satellite, cable and fiber.

[0009] However, as the demands for data volume and the pressure on available bandwidth continue to increase, the MPEG standards have difficulty compressing video sufficiently. Specifically, a video stream requiring less than 2 Macroblockits/sec of transmission bandwidth is now sought. However, the MPEG standards cannot provide adequate picture quality when compressing data to that degree.

[0010] Consequently, new compression techniques are being developed. One such technique is the H.26L standard being developed by the International Telecommunications Union. In testing, the H.26L standard is able to deliver a video stream using, e.g., 1.6 Macroblockits/sec of bandwidth while still maintaining image quality. To obtain comparable image quality with an MPEG-2 system, approximately twice as much bandwidth is required.

[0011] One problem with the H.26L standard, however, is its current lack of ability to handle interlaced video. The H.26L encoding standard has been developed largely without addressing the need to process interlaced video. Consequently, there is a need in the art for a means and method of adapting the H.26L encoding standard to handle interlaced video signals.

SUMMARY OF THE INVENTION

[0012] The present invention meets the above-described needs and others. Specifically, the present invention provides a means and method of adapting the H.26L encoding standard to handle interlaced video signals.

[0013] Additional advantages and novel features of the invention will be set forth in the description which follows or may be learned by those skilled in the art through reading these materials or practicing the invention. The advantages of the invention may be achieved through the means recited in the attached claims.

[0014] The H.26L encoding standard improves on the previously MPEG standards by requiring substantially less bandwidth to carry video of comparable quality. However, the

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H.26L standard does not at present contain any provisions for handling interlaced video. Consequently, interlaced video can be handled under the H.26L encoding standard by dividing each macroblock into blocks and then dividing each block into one of two fields within the frame. Alternatively, interlaced video can be handled under the H.26L encoding standard by dividing each macroblock into two fields and then dividing the fields in each macroblock into blocks. Motion compensated transformations are then performed on each field/block division effectively doubling the number of resulting motion vectors generated as compared to non-interlaced video. Using these methods, the H.26L encoding standard can be made to handle interlaced video.

Thus, the present invention encompasses a method of handling interlaced video during encoding and decoding under the H.26L standard by dividing each macroblock of each frame into a number of blocks; and dividing each block into top and bottom fields. Alternatively, the present invention also encompasses a method of handling interlaced video during encoding and decoding under the H.26L standard by dividing each macroblock of each frame into top and bottom fields; and dividing each field in each macroblock into a number of blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings illustrate preferred embodiments of the present invention and are a part of the specification. Together with the following description, the drawings demonstrate and explain the principles of the present invention. The illustrated embodiment are examples of the present invention and do not limit the scope of the invention.

[0016] Fig. 1 is an illustration of the division of a macroblock into sub-blocks or "blocks."

[0017] Fig. 2 is an illustration of the seven modes or patterns for dividing a macroblock into blocks in frame-based, non-interlaced video.

[0018] Fig. 3 is an illustration of the division of a block into fields for purposes of handling interlaced video.

[0019] Fig. 4 illustrates a first embodiment of the present invention in which macroblocks are divided into blocks which are then divided into two fields.

[0020] Fig. 5 illustrates a second embodiment of the present invention in which macroblocks are divided into two fields and then, within each field, further divided into blocks.

[0021] Fig. 6 is an illustration of the three modes which can be used with the intra prediction mode of the present invention.

[0022] Fig. 7 is an illustration of a macroblock divided into 16 blocks for explanation of the intra prediction mode of the present invention.

[0023] Fig. 8 is an illustration of three macroblocks each divided into 16 blocks for purposes of further explaining the intra prediction mode of the present invention.

[0024] Figs. 9a and 9b each illustrate three macroblocks each divided into 16 blocks for purposes of further explaining the intra prediction mode of the present invention.

[0025] Fig. 10 is an illustration of three macroblocks for purposes of explaining chroma prediction under the principles of the present invention.

[0026] Fig. 11 is an illustration of chroma data divided into top and bottom fields according to the present invention.

[0027] Fig. 12 is an illustration of blocks for purposes of explaining the inter coding mode of the present invention.

[0028] Fig. 13 is an illustration of three blocks for purposes of explaining loop filtering under the present invention.

[0029] Fig. 14 is an illustration of two possible scan patterns according to the present invention.

[0030] Throughout the drawings, identical elements are designated by identical reference numbers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] As noted above, H.26L is a new standard for compressing or encoding a video signal to decrease the required bandwidth for transmitting the video. The documents establishing the H.26L standard are hereby incorporated by reference, including "H.26L test

model long term number 8 (TML-8) draft" issued June 28, 2001 by the Video Coding Expert Group (VCEG) of the International Telecommunications Union (ITU-T). Due to the public nature of the H.26L standard, the present specification will not attempt to document all the existing aspects of H.26L video coding, relying instead on the incorporated specifications of the standard.

[0032] In summary, H.26L video coding is a motion compensated transform based method of video coding. The motion compensation (MC) and transform (T) are performed on a bloc-by-block basis. Each frame is divided into macroblocks (MBs). The typical macroblock is 16 x 16 pixels. Fig. 1 illustrates a frame (100) divided into macroblocks (101). Each macroblock is 16 x 16 pixels.

[0033] Each macroblock of 16x16 pixels can be further divided into blocks in one of seven patterns (modes). Fig. 2 shows the seven different modes into which each macroblock can be divided. As shown in Fig. 2, mode 1 makes now division of the macroblock. Thus, there is one block (0). In mode 2, the macroblock is divided vertically into two halves (0 and 1). In mode 3, the macroblock is divided horizontally into two halves (o and 1). In mode 4, the macroblock is divided into four blocks (0-3). In mode 5, the macroblock is divided in half horizontally. Then each half is divided into four blocks for a total of eight blocks (0-7). In mode 6, the macroblock is divided in half vertically. Then each half is divided into four blocks for a total of eight blocks (0-7). Finally, in mode 7, the macroblock is divided into 16 equal blocks (0-15). Thus, the size of a block can be 16 x 16 pixels (mode 1), 16 x 8 pixels (mode 2), 8 x 16 pixels (mode 3) 8 x 8 pixels (mode 4), 8 x 4 pixels (mode 5), 4 x 8 pixels (mode 6) and 4 x 4 pixels (mode 7).

[0034] A macroblock can be coded in either intra mode or inter mode. Intra mode means a macroblock is coded without temporal reference to other frames. Inter mode means a macroblock is coded with temporal prediction to the coded frames in the past or in the future. In both modes, data is removed from the macroblock to compress the total amount of data. In intra mode, the data is replaced when the video is decoded by looking at data in the preceding frame or frames. In inter mode, the data is replaced when the video is decoded by looking at other remaining data in the same frame.

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[0035] For intra mode, a macroblock can only be in either mode 1 (block size of 16x16 pixels) or mode 7 (block size of 4x4 pixels). For inter mode, a macroblock can be in any of the seven modes. Motion estimation and compensation (ME/MC) is performed for each blocks separately to generate a motion vector (MV). In other words, each block within a macroblock has a separate motion vector. Consequently, a macroblock can have up to 16 motion vectors (i.e., mode 7), depending upon the macroblock mode.

[0036] An integer transform of 4x4 is applied to each macroblock in either intra or inter mode. The block transform converts a block of highly correlated pixels into a block of uncorrelated coefficients. Hence, the following quantization can be performed on each individual coefficient. The block transform also compacts the block energy of a nature block into low-order coefficients of a block. Hence only the low-order coefficients need to be coded. The transform coefficients are quantized. The quantized transform coefficients are scanned and variable-length encoded. The transform used is part of the H.26L standard which is incorporated herein by reference.

[0037] As noted above, H.26L does not provide any tools for handling an interlaced video signal. Under the principles of the present invention, the ability to handle interlaced video can be incorporated into the H.26L method as follows.

[0038] To handle interlaced video, each block within each macroblock is further split into a top field and a bottom field. This division of each block within a macroblock is illustrated in Fig. 3. In Fig. 3, the shaded areas are in the top field and the unshaded areas are in the bottom field. As noted above, each block is composed of an array of N x M pixels, where N and M = 4, 8 or 16.

[0039] Under the principles of the present invention, the pixels of each such block are divided into two interlaced fields. As shown in Fig. 3, the block (130) on the left is divided into the two interlaced fields. The fields can be separated into a block (131) shown on the right.

[0040] Dividing each block into top and bottom fields creates seven more possible field-based block patterns within a macroblock. These patterns are illustrated in Fig. 4 (modes 1a - 7a). Again, The shaded areas are in the top field and the unshaded areas are in the bottom field. These patterns are essentially the same as illustrated in Fig. 2 and described

above. However each block is divided in half horizontally to provide an upper field and a lower field within each block.

[0041] In mode 1a, the macroblock is not subdivided into multiple blocks. The single block (or macroblock) (0) is then divided horizontally into top and bottom fields. In mode 2a, the macroblock is divided vertically into two blocks (0, 1). Each block is then divided horizontally into top and bottom fields. In mode 3a, the macroblock is divided horizontally into top and bottom blocks (0, 1). Each block is then divided horizontally again into top and bottom fields. In mode 4a, the macroblock is divided into four blocks (0 - 3). Each block is then divided horizontally into top and bottom field. In mode 5a, the macroblock is divided into eight blocks in a 2 x 4 array. Each block is then divided horizontally into top and bottom fields. In mode 6a, the macroblock is divided into eight blocks in a 4 x 2 array. Each block is then divided horizontally into top and bottom fields. In mode 7a, the macroblock is divided into sixteen blocks in a 4 x 4 array. Each block is then divided horizontally into top and bottom fields.

[0042] Under the principles of the present invention, the ME/MC calculation is then performed on each field separately to generate a motion vector (MV) for each field in each block of the macroblock. Consequently, there may be up to 32 MVs for a single macroblock, assuming the pattern of mode 7a.

[0043] In inter mode encoding, under the H.26L standard (which is incorporated herein by reference), there must be corresponding reference areas in the previous frame or frames that are used during decoding to extrapolate data removed from the current frame during encoding. Under the principles of the present invention, the reference field or fields for a field-based block can be either the top or the bottom fields of the previous frame or frames.

[0044] Seven field-based ME/MC code modes can be the possible code modes in encoding a macroblock. These additional field-based code modes can be compared with frame-based code modes. The same criteria, such as the sum of absolute differences (SAD) with/without bias or rate distortion (RD) basis, can be used in determining the code mode for a macroblock. In other words, there are different modes available in frame-based and field-based coding. Which mode is selected can be determined by the associated SAD or RD basis.

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[0045] An alternative approach under the principles of the present invention is illustrated in Fig. 5. Under this approach, rather than dividing each block into top and bottom interlaced fields, each macroblock is first split into two fields, top and bottom. The split macroblock is then further divided into blocks.

[0046] As shown in Fig. 5, there are five possible modes or patterns (mode 1b - 5b). In mode 1b, the macroblock is divided horizontally into top and bottom fields. The macroblock is then further divided into two blocks that correspond to the two fields. In mode 2b, the macroblock is divided horizontally into top and bottom fields. The macroblock is then divided into four blocks, two in each field. In mode 3b, the macroblock is divided horizontally into top and bottom fields, and then into eight blocks, four in each field aligned in a 4 x 4 array. In mode 4b, the macroblock is divided horizontally into top and bottom fields. And then into eight blocks, four in each field aligned in a single row. In mode 5b, the macroblock is divided horizontally into top and bottom fields and then divided into 16 blocks, eight in each field in a 2 x 4 array.

[0047] The ME/MC calculation is then preformed on each block in each field. There are up to 16 blocks of 4 pixels x 4 pixels, e.g., mode 5b. Consequently, there may be as many as 16 motion vectors (MVs) per macroblock. The smallest block size is 4 pixels x 4 pixels. Therefore, a fixed-size transform of that operates on a 4 x 4 pixel matrix can still be applied. This will reduce initial development work on interlaced video sequences and is consistent with the H.26L standard.

[0048] An additional field 16 x 16 mode is also proposed under the principles of the present invention. In the new mode, the macroblock is split into top and bottom fields. The motion estimation for the top and bottom fields is done in a similar fashion to the motion estimation for the 8 x 16 mode except in the new 16 x 16 field mode, the motion vectors for the top and bottom fields are constrained to be the same. Furthermore, the reference field used for predicting the bottom field is used as the field subsequent to the reference field for the top field. This additional mode has the advantage that is uses fewer bits for coding motion vectors and the extra reference field information for the bottom field.

[0049] H.26L allows multiple reference frames for temporal prediction. Reference frames are the anchor frames used for temporal prediction. Temporal prediction is

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used as follows. Instead of coding the current frame directly, the difference between the current frame and the anchor frame is coded. The anchor frames are the previously coded frames. Thus, the current frame can be reconstructed starting with the anchor frame and implementing the differences which have been coded between the current and anchor frames.

[0050] The reference frame for a macroblock has to be indicated in the syntax at the macroblock level. TML8 (frame-based) assigns code number 0 to the most recent coded frame, 1 to the second most recent coded frame, and so on. This means the closer the reference frame to the current frame, the more likely the reference frame will be selected, and hence the shorter are the code words assigned. For field-based motion estimation, the reference can be either the top or the bottom field. The reference field will be indicated in the syntax at the macroblock level.

[0051] Preferably, under the present invention:

[0052] 1. The code numbers assigned for field-based references stored in reference frame buffer are slightly different from the frame-based references. Specifically, the code numbers of 0, 1, 2, 3, ..., are grouped into pairs of (0,1), (2,3), (4,5), ... The code number pairs are assigned to the reference frames of two fields according to their distances to the current frame. For each reference frame, the field of the same parity as the current field is given the smaller number of the code number pair assigned for the frame.

[0053] 2. Code number pairs are assigned to the reference frames of two fields according to their distances to the current frame.

[0054] 3. For each reference frame, the field of the same parity as the current field is assigned the smaller number of the code number pair assigned for the frame.

[0055] Both the encoder and the decoder follow this rule.

[0056] In addition, each field within a macroblock is treated as an independent macroblock in the sense that it can have its own reference number. Thus, a field in the current frame may have two references which are both corresponding fields from different frames. Consequently, two codes are put in the syntax at the macroblock level to indicate both the reference frame and the reference field when interlaced video is being processed.

[0057] I frame video is coded without reference to other frames. Intra-prediction mode: spatial prediction is performed in I frame. For I frame, only mode 1, mode 7 and mode

5b are allowed, as shown in Fig. 6. Modes 1 and 7 are frame-based and mode 5b is field-based.

[0058] Intra prediction for modes 1 and 7 will follow TML8, i.e., the H.26L standard. Intra prediction mode for mode 5a will operate as follows under the principles of the present invention. Fig. 7 illustrates a block (170) which is divided according to mode 5a into 16 blocks (a - p). Each block (a - p) corresponds to a single pixel. For intra prediction, pixels of the same field parity that neighbor or border the pixel being processed are used. In some instances this neighboring pixels will be in the same macroblock. In other instances, the neighboring pixels will be in an adjacent macroblock, e.g., pixels (A - I) from the macroblocks above and to the left of the current macroblock.

[0059] A more specific example is illustrated in Fig. 8. Three macroblocks (170, 171, 172) are shown. Each macroblock is divided into 16 blocks of one pixel each according to mode 5a. As before, shaded blocks are in a top field and unshaded blocks are in a bottom field. Macroblock (170) is the current macroblock being processed, while macroblock (171) is to the left, and macroblock (172) is above.

[0060] As shown in Fig. 8, the neighboring pixels for blocks 5, 6 and 7 of macroblock (170) are blocks 4, 0, 1, 2 and 3 in the same macroblock (170). The neighboring pixels for block 7 of the current macroblock (170) are blocks 2, 3, and 6 in the same macroblock (170). Blocks 2, 3, and 6 are of the same field parity as block 7 and thus can be used for intra prediction for block 7. The left neighboring pixels for blocks 0 and 4 in the current macroblock (170) are blocks 3 and 7 of the left macroblock (171). Again, blocks 3 and 7 of the left macroblock (171) are of the same field parity as blocks 0 and 4 of the current macroblock (170). The above neighboring pixels for blocks 0, 1, 2 and 3 of the current macroblock (170) are blocks 4, 5, 6 and 7 of the above macroblock (172). Blocks 8 to 15 of the above macroblock (172) are not used because they are of a different field parity than blocks 0 to 3 of the current macroblock (170).

[0061] Note that the left and above macroblocks can be coded in either a frame- or field-based manner. Turning to Fig. 9, assume that the current macroblock (170) is coded in two fields, as shown in Fig. 9a. As before, the shaded area is the top field, the unshaded area the bottom field. As would be the case in a frame-based macroblock, the prediction mode of

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a 4 x 4 field-based block is coded based upon the prediction modes of the neighboring blocks. For interior blocks of a field-based macroblock (e.g., 5, 6, 7, 13, 14 or 15; Fig. 8), the neighboring blocks of the same field parity used in the coding of intra prediction mode are simply the adjacent blocks in the same macroblock. Identically, in Figs. 9a and 9b, the neighboring blocks of block C are blocks A and B. For blocks on the boundary with another macroblock (e.g., 0, 1, 2, 3, 4, 8, 9, 10, 11, and 12 of Fig. 8), the neighboring blocks used in intra prediction mode coding are defined as follows:

[0062] 1. If the above (172) or the left (171) macroblock is also coded in fields, as shown in Fig. 9a, the neighboring blocks for the boundary blocks in the current macroblock (170) have the same field parity. For example, the neighboring blocks for blocks C' and C'' in macroblock (170) are A' and B', and A'' and B'', respectively.

[0063] 2. If the above (172) or the left (171) macroblock is coded in frame-based manner, as shown in Fig. 9b, the neighboring blocks of the boundary blocks in the current macroblock (170) are on the right edge of the left macroblock (171) or on the bottom of the above macroblock (172). For example, the neighboring blocks for blocks C' and C'' of the current macroblock (170) are A' and B', and A'' and B', respectively, in the left (171) and above (172) macroblocks.

[0064] There is only one prediction mode for interlaced chroma blocks. As shown in Fig. 10, there are four 8 x 8 pixel chroma blocks (A- D) of a macroblock (170). Blocks A and B are in the top field and blocks C and D in the bottom field. S0, S1, S2, S3, S4, S5 are the sums of the neighboring pixels of A, B, C and D in the same field parity. The S0, S1 and S2 areas are calculated from the top field, while the S3, S4 and S5 areas are calculated from the bottom field.

[0065] If S0, S1, S2, S3, S4 and S5 are all inside the frame, the chroma predictions for blocks A, B, C and D are as follows:

[0066] A=(S0+S2+4)/8

[0067] B=(S1+2)/4

[0068] C=(S3+S5+4)/8

[0069] D=(S4+2)/4

[0070] If only S0, S1, S3 and S4 are inside the frame, the chroma predictions for blocks A, B, C and D are follows:

[0071] A=(S0+2)/4

[0072] B=(S1+2)/4

[0073] C=(S3+2)/4

[0074] D=(S4+2)/4

[0075] If only S2 and S5 are inside the frame, the chroma predictions for blocks A, B, C and D are as follows:

[0076] A=(S2+2)/4

[0077] B=(S2+2)/4

[0078] C=(S5+2)/4

[0079] D=(S5+2)/4

[0080] If the luminance component is coded in a field-based manner, the chroma component will follow. The chroma will be split into the top and the bottom fields, as shown in Fig. 11. A 4 x 4 transform is performed on each block composed of a 4 X 4 array of pixels. The DC coefficients are then grouped into two 2 x 2 blocks. A 2 x 2 transform is then performed on the two 2 x 2 DC blocks.

[0081] The generation of prediction motion vectors (PMVs) in an inter coded prediction mode under the principles of the present invention will now be explained. Referring to Fig. 12, assume block E is inter coded. The associated MV will be differentially coded as well. The prediction MV of block E is the median of the MVs of the neighboring blocks A, B, C and D, as shown in Fig. 12. Block E can be either a frame-based or a field-based block. In other words, all the frame- and field-based modes are allowed.

[0082] 1. If E is a macroblock in a frame-based video, the MVs of A, B, C and D used in calculating the PMV for E are also frame-based. If block A, B, C, or D is coded in a field-based video, the two field MVs are averaged and the vertical component is multiplied by 2.

[0083] 2. If E is a macroblock in a field-based video, the MVs of blocks A, B, C and D are used in calculating PMV and are also field-based in the same field parity. If block A, B, C, or D is coded in a frame-based manner, the vertical component of MV is divided by 2.

[0084] For directional segmentation, follow the same conventions as in TML8 provided that the neighboring blocks are of the same field parity.

[0085] Loop filtering is also involved in processing of the neighboring pixels. Referring to Fig. 13, let C be the current block, and A and B are the left and above neighboring blocks, respectively. Block C, A, or B can be coded in either frame- or field-based video. The rules for loop filtering under the principles of the present invention are as follows:

[0086] 1. If block C is coded as frame-based and block A is also as frame-based, the filtering crossing A and C will be frame based.

[0087] 2. If block C is coded as frame-based and block A is coded as field-based, the filtering crossing A and C will be filed based.

[0088] 3. If block C is coded as field-based and block A is coded as frame-based, the filtering crossing A and C will be field based.

[0089] 4. If block C is coded as field-based and block A is also coded as field-based, the filtering crossing A and C will be field based.

[0090] 5. If block C is coded as frame-based and block B is also coded as frame-based, the filtering crossing B and C will be frame based.

[0091] 6. If block C is coded as frame-based and block B is coded as field-based, the filtering crossing B and C will be field based.

[0092] 7. If block C is coded as field-based and block B is coded as frame-based, the filtering crossing B and C will be field based.

[0093] 8. If block C is coded as field-based and block B is also as field-based, the filtering crossing B and C will be field based.

[0094] As indicated above, a block sizes within a macroblock can have the following possible dimensions in terms of pixels: 16 x 16, 16 x 8, 8 x 16, 8 x 8, 8 x 4, 4 x 8, or 4 x 4 for frame-based blocks, and 16 x 8, 8 x 8, 4 x 16, 4 x 8, 4 x 4, 2 x 8, or 2 x 4 for

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field-based blocks. Under the principles of the present invention, it is possible that a variable-size integer transform be used, instead of fixed 4 x 4 transform. In other words, the transform size alters to matches the block size. While work on variable-size integer transforms is still ongoing, it is worth noting that such transforms can be used within the scope and principles of the present invention.

[0095] Human eyes have different sensibility to coding distortions at different frequencies. In general, the distortion for lower frequency coefficients is much more visible than for higher frequency coefficients. Consequently, a non-uniform quantization matrix, such as is used in the MPEG standard, often achieves better performance than a uniform matrix. Therefore, under the present invention, a non-uniform quantization matrix is preferably introduced into the H.26L standard as well.

[0096] The quantization matrix used will have to become a set of the quantization matrices if variable-size transforms are to be accommodated. Furthermore, the quantization matrices will not be symmetric. In particular, the DC coefficients need to be treated slightly different from the AC coefficients. Specifically, we can set a smaller Quantizer Parameter ("QP") for DC than AC, for example, $QP_{DC} = QP_{AC} - n$ where n is a constant.

[0097] Or we can specify the QP for the coefficients at different frequency orders. For example,

$$QP(i,j) = \begin{cases} q_0, & i+j=0 \\ q_1, & i+j=1 \\ q_2, & i+j=2 \\ q_3, & i+j=3 \\ \cdots & \cdots \end{cases}$$

where (i,j) are the coefficient indices.

[0098] If variable-size transforms are used, the transformed blocks are no longer square. Consequently, the scanning path needs to be redesigned also. The scanning path is the path that the encoder or decoder moves through the frame to encode or decode the video.

[0099] Under the present invention, the default scanning path preferably starts with the DC coefficient, and then moves to the next, either vertically or horizontally,

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depending upon whether N > M, or N < M. Two possible scanning paths are shown in Fig. 14. A possible criterion in designing a scanning path is that the coefficient energy monotonically decreases along the scanning path.

[00100] The scanning pattern for interlaced blocks should follow the path that reaches the majority of the nonzero coefficients. The simple scan (zig-zag pattern) may not be best suited for interlaced video. Thus, interlaced video should use an alternate vertical scan pattern to scan its quantized coefficient.

[00101] The easiest way is to include the field-based code modes in the macroblock_type field. That is, in addition to inter frame blocks of 16 x 16, 16 x 8, 8 x 16, 8 x 8, 8 x 4, 4 x 8, and 4 x 4, add inter field blocks of 16 x 8, 8 x 8, 4 x 16, 4 x 8, 4 x 4, 2 x 8, and 2 x 4. H.26L uses Universal Variable Length Codewords ("UVLC"). Hence, the additional field-based code modes can be easily included. For example, frame-based inter modes use the code numbers from 0 to 6, and the field-based inter modes can use the code numbers from 7 to 13. Intra modes then follow.

[00102] The macroblock_type indicates what fields will follows, and how these fields will look. For example, if the macroblock_type is frame-based inter coding of 4 x 4, 16 MVDs will follows in Motion Vector Data (MVD) field. If the macroblock_type is field-based inter coding of 2 x 4, there will be 32 MVDs in the MVD field.

[00103] Another way to identify the mode for a field-based macroblock is by introducing a new flag for "frame" or "field" coding at the macroblock level. When this flag is enabled, the meaning of the macroblock structure changes to its corresponding field type hence no new entry in the UVLC table is necessary. See Fig. 15.

[00104] There is additional information that should to be included in the bitstream so that the decoder can process it correctly. For example, when texture, motion and the deblocking process can be performed independently (either field or frame based), extra information is needed either in the form of extra flags or new entries in UVLC table.

[00105] Under the principles of the present invention, a frame can be encoded on either a frame- or field basis. That is, there is frame/field encoding adaptation on a frame-by-frame basis. The criterion for choosing frame- or field-based coding per frame can be the numbers of bits resulting from either frame- or field-based coding, or a cost function of

distortion compared to the number of bits. However, a B picture always codes the same way as its backward anchor picture. Specifically,

[00106] 1. An I frame may be encoded as either an I frame, or two I fields, or one I field and one P field

[00107] 2. A P frame may be encoded as either a P frame, or two P fields, or one P field and one B field

[00108] 3. A B frame may be encoded as one B frame, or two B fields, depending upon the type of the future reference (I or P).

[00109] In addition, for field-based B frames, there can be multiple references for forward prediction, and the references can be any coded I or P field. However, there is only one reference for backward prediction, and the reference is always the most recently coded future I or P of the same field parity. For direct mode macroblock, the two MVs are calculated from the co-located macroblock in the future reference of the same field parity.

[00110] Sometimes a frame is skipped. By skipping a frame, it is meant that: in a frame based video, a frame is skipped, in a field based video, a frame comprising two fields is skipped.

[00111] In order to guarantee the performance of field-based coding, it may be necessary to have the same modes for the field-coded macroblock as for the frame-based coding. In other words, a frame-coded macroblock can have seven possible modes, as shown in Fig. 2, and a field coded macroblock should have seven possible modes as well. A super-macroblock is therefore introduced as follows:

[00112] Input frame is divided into super macroblocks consisting of two 16 x 16 macroblocks as shown in Fig. 16. A super macroblock can be coded as two frame-based macroblocks of 16 x 16, or one top-field macroblock and one bottom-filed macroblock of 16 x 16. For field-based coding, a super macroblock is split into a top-field and a bottom-field macroblock, as shown in Fig. 17. The top- and the bottom-field macroblock are further divided into one of seven block patterns (modes 1a-7a) in Fig. 17) similar to the frame-based block patterns.

[00113] There are two possible coding paths. See Fig. 18. One path is horizontal where the super macroblocks of a frame are coded from left to right, and top to bottom.

Alternatively there is a vertical path where the super macroblocks of a frame are coded from top to bottom and left to right. For frame-based coding, the top macroblock of a super macroblock is coded first, followed by the bottom macro-block. For field-based coding, the top field macroblock of a super macroblock is coded first, followed by the bottom-field macroblock. For horizontal path PMV of the current block follows the same way described in Fig. 9. For vertical path, the neighboring blocks (A, B, C, D) of the current block E are however defined as shown in Fig. 19.

[00114] The advantage of the horizontal path is that it follows the traditional path. But a minor problem is that the info on block C, such as MVs is not available (See Fig. 9). The advantage of the vertical path is that the info on all the neighboring blocks is available for the current block E, see Fig. 19.

[00115] The preceding description has been presented only to illustrate and describe the invention. It is not intended to be exhaustive or to limit the invention to any precise form disclosed. Many modifications and variations are possible in light of the above teaching.

[00116] The preferred embodiment was chosen and described in order to best explain the principles of the invention and its practical application. The preceding description is intended to enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims.

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WHAT IS CLAIMED IS:

1. A method of handling interlaced video during encoding and decoding under the H.26L standard, said method comprising:

dividing each macroblock of each frame into a number of blocks; and

dividing each block into top and bottom fields.

2. A method of handling interlaced video during encoding and decoding under the H.26L standard, said method comprising:

dividing each macroblock of each frame into top and bottom fields; and

dividing each field in each macroblock into a number of blocks.

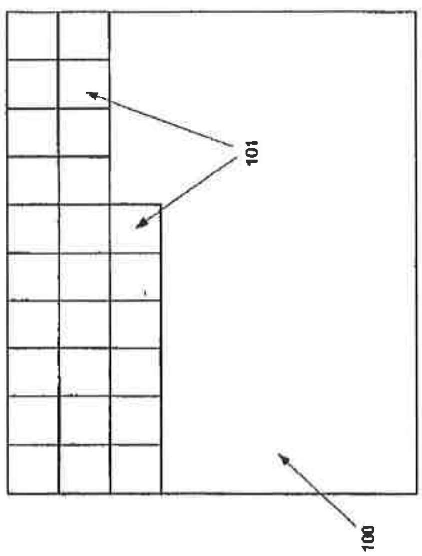
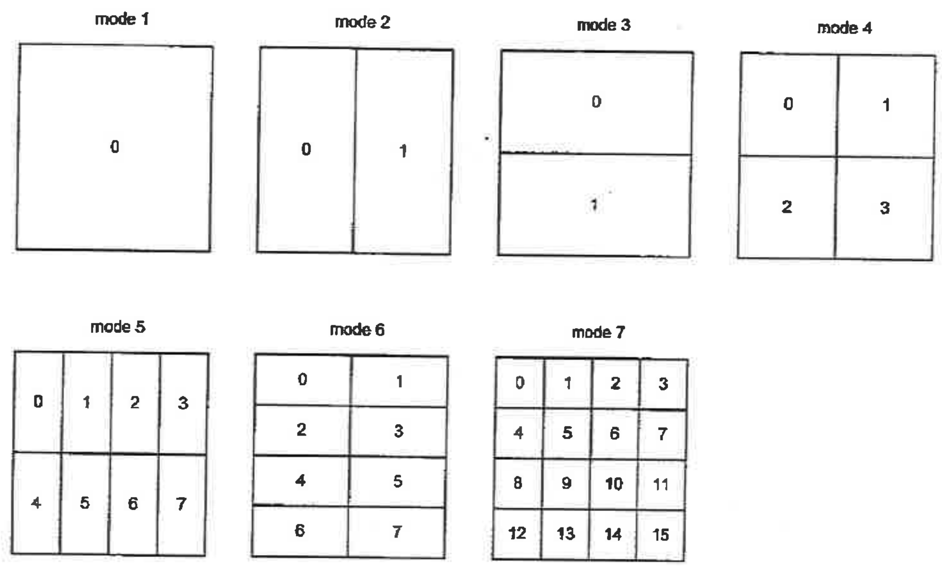


Fig. 1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mode 2
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1
mode 3
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1
mode 4
0
1
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mode 5
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1
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3
4
5
6
7
mode 6
0
1
2
3
4
5
6
7
mode 7
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1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Fig. 2

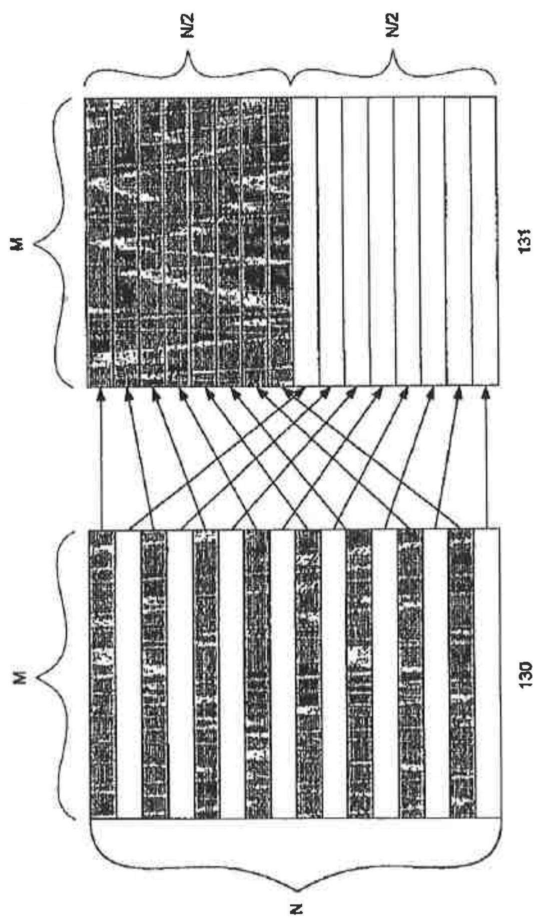


Fig. 3

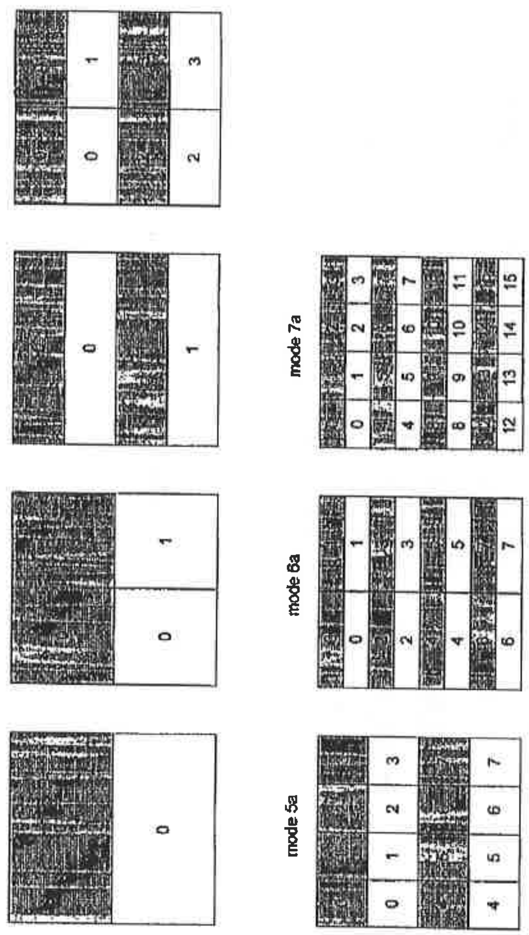
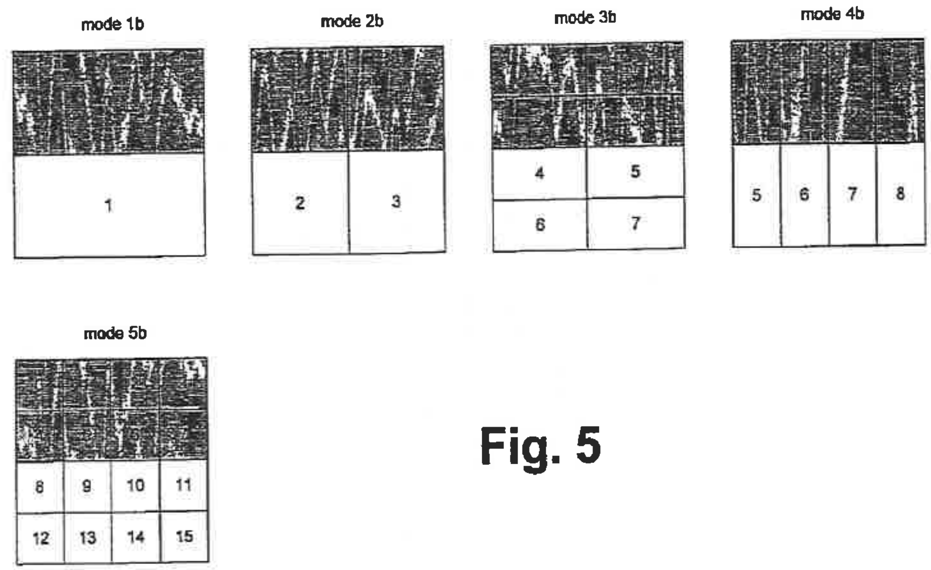


Fig. 4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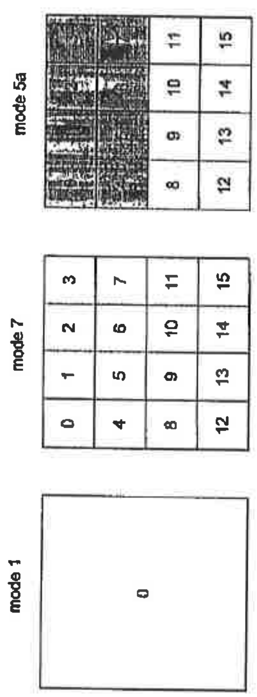
mode 2b
2
3
mode 3b
4
5
6
7
mode 4b
5
6
7
8
mode 5b
8
9
10
11
12
13
14
15

Fig. 5


mode 1
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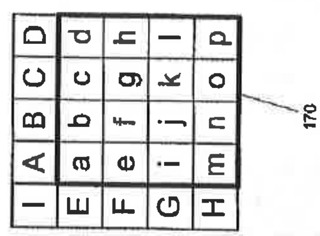
mode 7
0 1 2 3
4 5 6 7
8 9 10 11
12 13 14 15
mode 5a
8 9 10 11
12 13 14 15

Fig. 6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E a b c d
F e f g h
G i j k l
H m n o p
170

Fig. 7

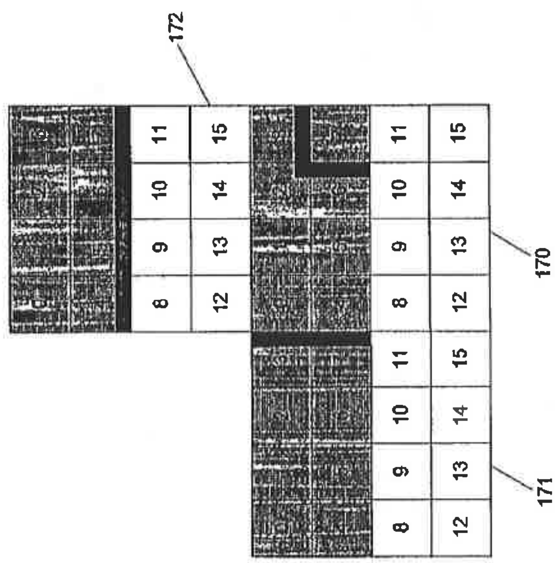


Fig. 8

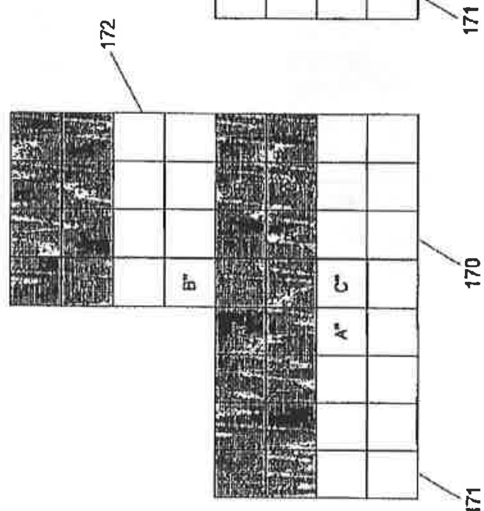


Fig. 9a

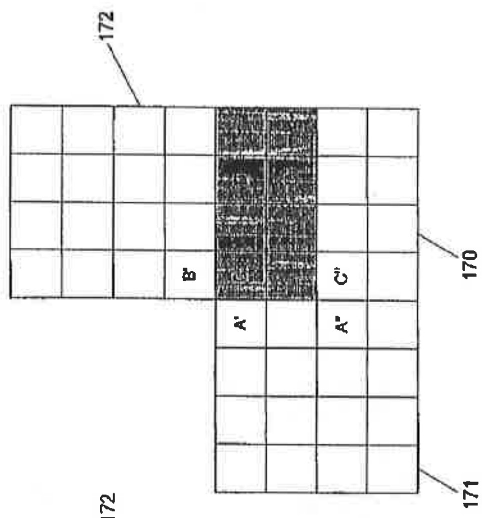


Fig. 9b

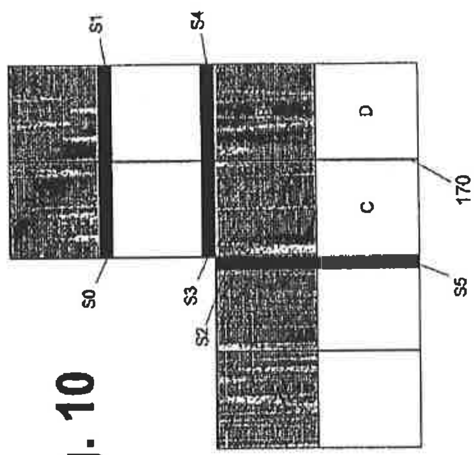


Fig. 10

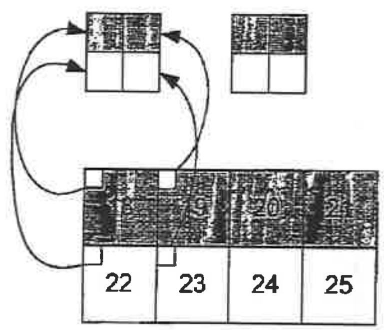


Fig. 11

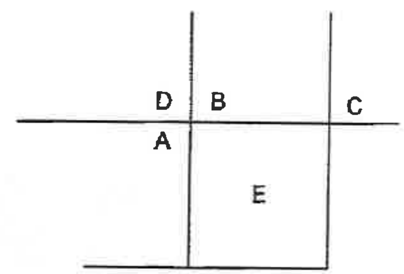


Fig. 12

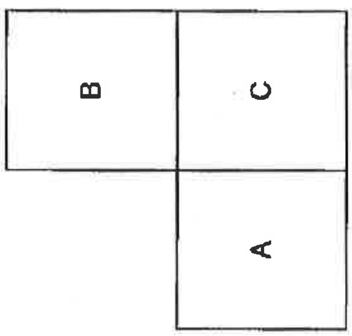


Fig. 13

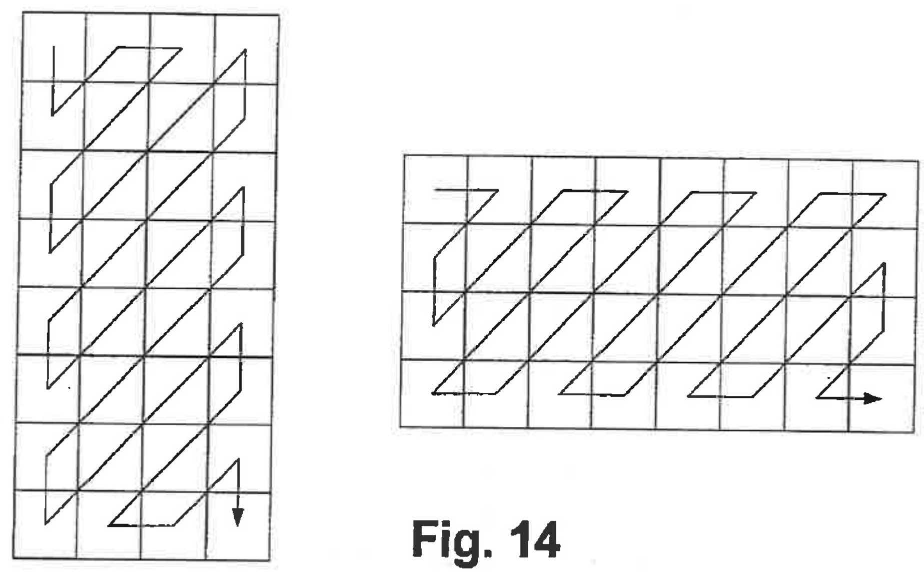


Fig. 14

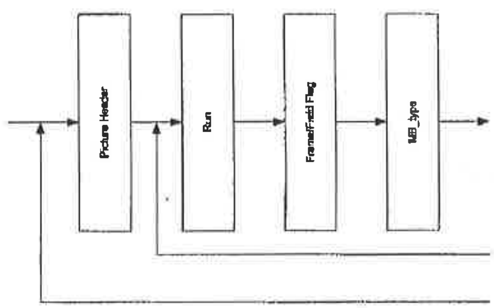


Fig. 15

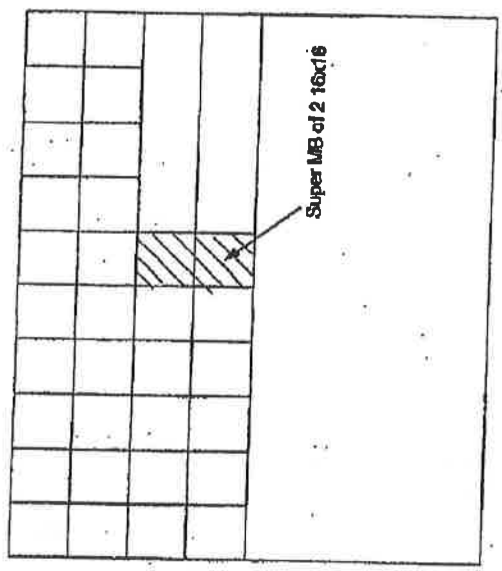


Fig. 16

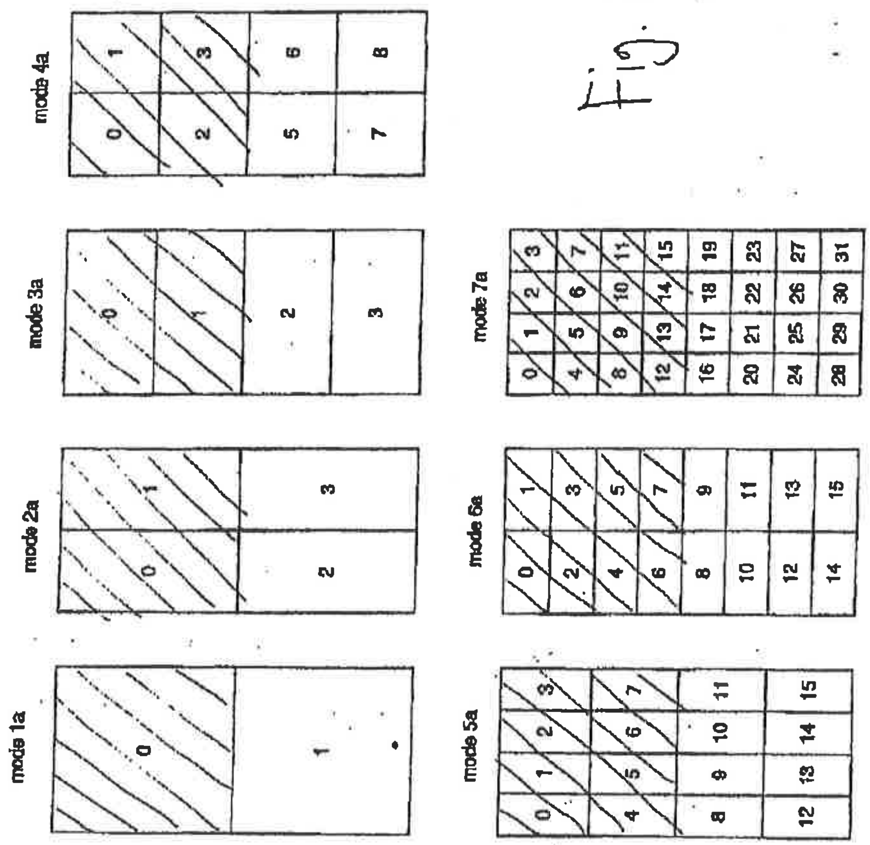


Fig. 17

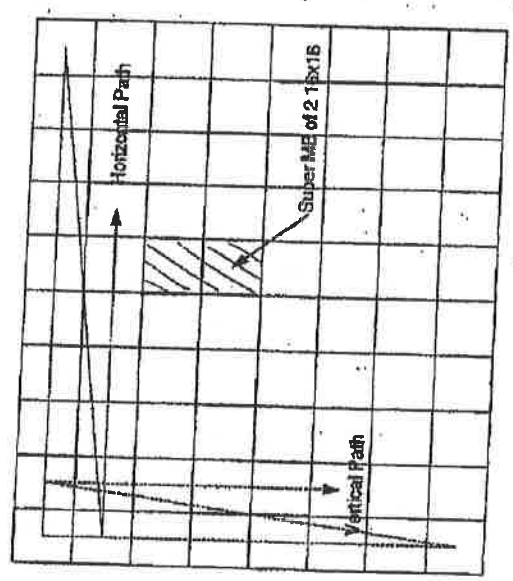
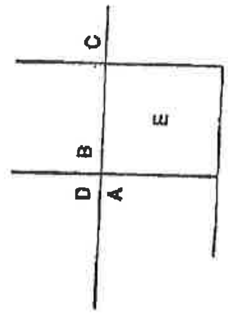


Fig 18



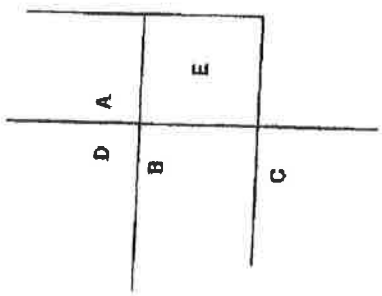


Fig 19

Exhibit L

To

Joint Claim Chart

File History Report

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- ☐ **Cover page**

Additional comments:_____

60/395,734

Macroblock adaptive frame/field coding for interlace sequences

Transaction History

Date	Transaction Description
7/12/2002	Initial Exam Team nn
7/26/2002	IFW Scan & PACR Auto Security Review
7/31/2002	Application Is Now Complete
8/1/2002	Application Dispatched from OIPE
9/1/2003	EXPIRED PROVISIONAL

07/12/02 J1054 U.S. PTO

60395734.071202

07-15-02

A/PROV

PTO/SB/16 (10-01)
Approved for use through 10/31/2002 OMB 0651-0032
U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EU215591021US

J1011 U.S. PTO 60/395734 07/12/02

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Yue	Yu	San Diego, California U.S.A
Ajay	Luthra	San Diego, California U.S.A.

☐ Additional inventors are being named on the ______ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

Macroblock Adaptive Frame/Field Coding for Interlace Sequences

CORRESPONDENCE ADDRESS

Direct all correspondence to:

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Address					
Address					
City		State		ZIP	
Country		Telephone		Fax	

ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages 9 ☐ CD(s), Number

☐ Drawing(s) Number of Sheets ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 18-0013

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($) $160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ______

Respectfully submitted,

SIGNATURE [signature]

Date July 12, 2002

TYPED or PRINTED NAME Steven L. Nichols

REGISTRATION NO (if appropriate) 40,326

Docket Number: JVT-C139

TELEPHONE 801-572-8066

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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60395734.071202

Title:	**Macroblock Adaptive Frame/Field Coding for Interlace Sequences**
Status:	Input Document to Joint Video Team (JVT)
Purpose:	Proposal
Author(s) or Contact(s):	Limin Wang, Rajeev Gandhi, Krit Panusopone, Yue Yu and Ajay Luthra
Source:	Motorola Inc.

Abstract
This document presents the results of Macroblock (MB)-level adaptive frame/field (AFF) coding for interlaced video materials, and the performance comparisons with picture level adaptive frame/field coding [3]. The simulation results show that MB level adaptive coding can provide additional gain over picture level adaptive coding for sequences that favor frame coding. It is also suggested that MB level adaptive frame/field coding can be integrated in picture level adaptive coding. Integration of MB level and picture level adaptive coding guarantees the performance over both MB level and picture level adaptive coding.

1. Introduction
A frame of an interlace video sequence consists of two fields, scanned at different time instants. The two fields of a frame can be coded jointly (e.g. frame-based coding) or separately (e.g. field-based coding). The decision on frame or field coding can be made at either picture level [3] or MB level [4].

Picture level adaptive frame/field coding demonstrates a significant improvement over fixed frame or field coding [3]. In this document, the decision on frame/field coding is moved to MB level. A MB can now be coded in either frame or field mode. This MB level adaptive frame/field coding is aligned with core experiment for interlace coding defined in [2]. The simulation results show that MB level adaptive coding gives an additional gain over picture level adaptive coding for the sequences that favor frame coding. MB level coding can be integrated into picture level adaptive coding as well.

2. Adaptive Frame/Field Coding at MB level
In MB level adaptive coding, the selection of frame or field coding is at MB level. A frame/field flag of one bit may therefore be required at MB level to indicate if the MB is coded in frame or field mode, as shown in Fig. 1. "0" can be used to indicate frame coding and "1" field coding. For detailed information on MB level coding, refer to [8].

[redacted]

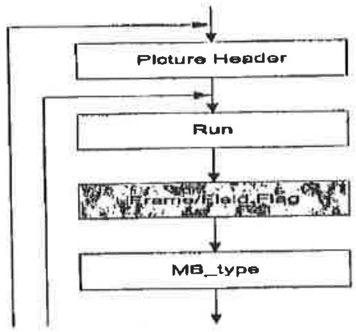

Fig. 1. A frame/field flag of one bit may be required to indicate if the MB is coded in frame or field mode.

2.1 Modes for Regular MB

A MB of 16x16 can be divided in one of seven patterns (modes) [1], as shown in Fig. 2. The associated block size for the seven modes are 16x16, 16x8, 8x16, 8x8, 8x4, 4x8, and 4x4. A MB can be coded in either intra or inter. For intra mode, MB can be only in either mode 1 (block size of 16x16) or mode 7 (block size of 4x4). For inter mode, MB can be in any of seven modes. Motion estimation and compensation (ME/MC) is performed for these blocks separately. In other words, each block within a MB has a separate motion vector (MV), and hence, a MB can have up to 16 MVs, depending upon the MB mode.

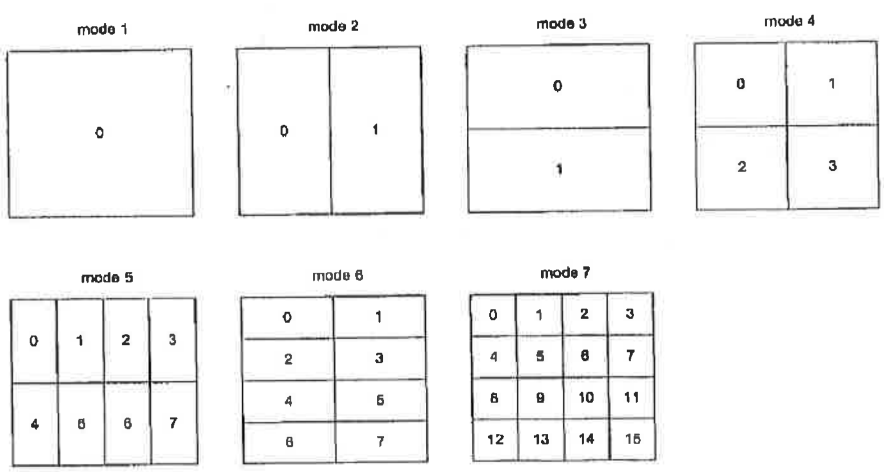

Fig. 2. Seven block patterns for a MB.

[redacted]

2.2 Modes for Super MB

The concept of super MB was introduced for interlace coding in [4]. A super MB consists of 2 MBs of 16x16, as shown in Fig. 3. A super MB of 32x16 can be coded as two frame MBs of 16x16, or one top-field MB of 16x16 and one bottom-field MB of 16x16. For frame coding, a super MB is coded as two frame MBs and each of two MBs can be further divided into one of seven modes, as shown in Fig. 2. For field coding, a super MB is first split into one top-field MB and one bottom-field MB, as shown in Fig. 4. The top-field, or the bottom-field, MB is further divided into one of seven block patterns (modes 1a – 7a), as shown in Fig. 4. The block size in the seven modes can be 16x16, 16x8, 8x16, 8x8, 8x4, 4x8 or 4x4, – the same as for frame MB (Fig. 2).

Motion compensation for Super MB is performed in the same way as described in [1]. Each MB in a Super MB has its own reference frame. When a Super MB employs field mode, one field MB may use any field of any picture in the reference frame buffer. Reference frame information (ref_frame) of Super MB in field mode determines which field is used for motion compensation. The field notation is set in favor to the same field; i.e., the lower number to the same field parity. For example, the top field MB of a Super MB with ref_frame = 0 points to the top field of the previous reference picture. Similarly, the bottom field MB of a Super MB with ref_frame = 1 points to the top field of the previous reference picture.

The coding rules for super MB, such as intra prediction, reference frame/field and the assignment of code numbers for reference fields in the reference frame (field) buffer, follows the same as described in [5]. For the skipped MB (copy mode), if in field, it is reconstructed by copying the co-located MB in the most recently coded (past) I or P field of the same field parity.

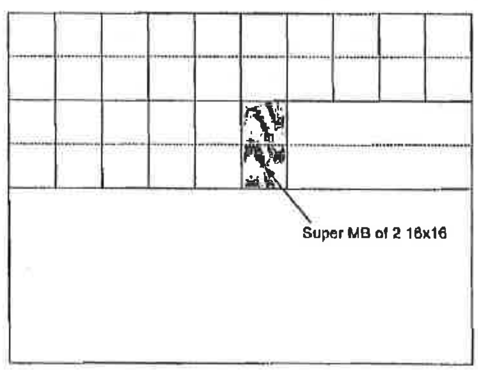

Fig. 3. Input frame is divided into super MB of 2 16x16 pixels.

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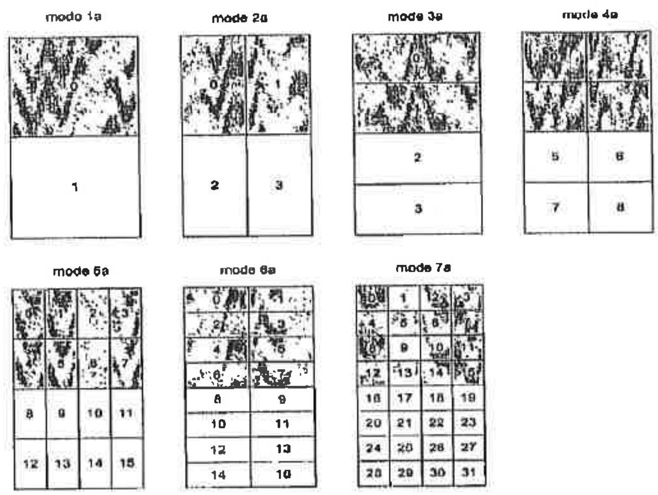

Fig. 4. For field-based coding, a super MB is split into a top-field MB and a bottom-field MB. The top- and the bottom-field MB is further divided into one of seven block patterns (modes).

Super MBs of a frame are coded from left to right, and top to bottom. For frame-based coding, the top MB of a super Mb is coded first, followed by the bottom MB. For field-based coding, the top-field MB of a super MB is coded first followed by the bottom-field MB. For horizontal path, PMV of the current block follows the same rules described in [1]. The neighboring blocks (A, B, C, D) of the current block E are defined as in [1].

3. Encoder Architectures with MB level Adaptive coding

Fig. 5 and 6 shows two possible encoder architectures with MB level adaptive coding. In Fig. 5, the input frame is always coded as one frame picture. Adaptation of frame/field coding is made on each MB (or super MB). The decision on frame or field coding for a MB (or super MB) can be RD-based. In Fig. 6, the input frame can be coded in either frame or field structure. For frame picture, a MB (or super MB) can be coded in frame or field mode. The decision on frame or field coding for a MB (or super MB) can be RD-based. For field picture, there is no MB level adaptive frame/field coding and two fields of a frame are coded sequentially. Note that the 1st coded field of a frame, if I or P, can be used as reference field for the 2nd field of the same frame.

The decoder will learn the picture structure of the incoming frame from PSTRUCT in picture header [6]. For PSTRUT=0 (frame coding), the decoder can expect that some of MB in the picture may be coded in frame mode and others in field mode.

[redacted]

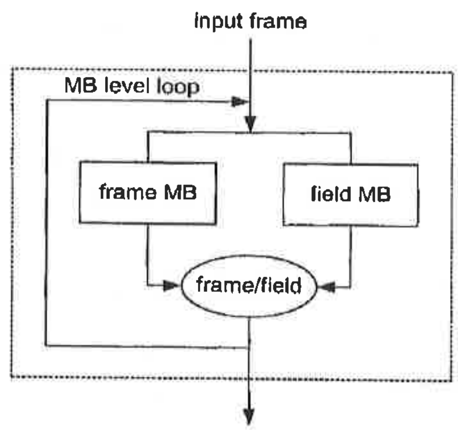

Fig. 5. A MB can be coded in either frame or field mode.

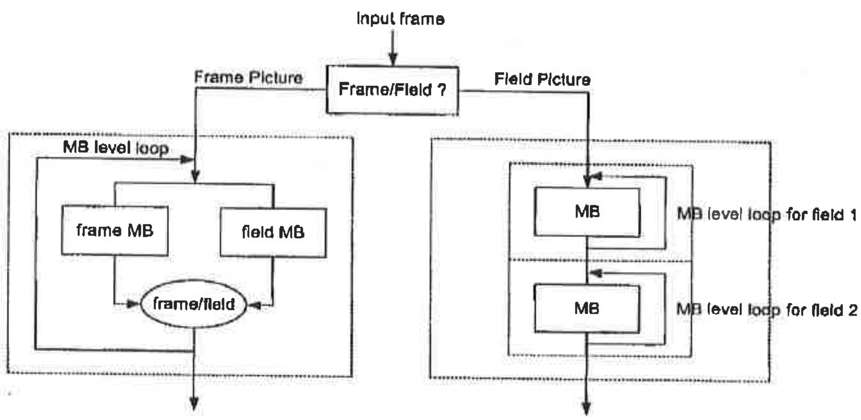

Fig. 6. Input frame can be in either frame or field structure. For frame coding, MB can be coded in either frame or field mode. For field coding, the first coded field, if I or P, can be used as reference field for the second field of the same frame.

4. Computer Simulations

Simulations were carried out for six video sequences, as shown in Table 1, where the first three sequences are the common test sequences selected for interlace coding core experiment [2]. For comparison purpose, three encoder architectures, picture level adaptive coding, MB level adaptive coding (Fig. 5) and MB/picture level adaptive coding (Fig. 6), were performed for these

sequences separately. A set of four quantization parameters (QP) was used per test per sequence, where QP for I and P are 16, 20, 24, and 28 and . Other coding parameters are listed in Table 2. Two picture structures are used in simulations. They are IPPPPP… and IBBPBBP….

Table 1. Test Sequences

	Format 4:2:0	*Length*	*Frame/Second*
Canoa	720x576	220	25
Rugby	720x576	220	25
Mobile	720x480	260	30
Tempete	720x480	260	30
Coastguard	720x480	260	30
Ice Hockey	528x480	300	30

Table 2. Test conditions

Entropy C.	MC	Hadamard	Ref. Frames	Search Res.	RD Opt.	Search R.
UVLC	1/4 pel	Yes	2	2	Yes	16

The results are presented in terms of the % saving in bits calculated by using the SW provided by Real Network (Bjontegaard Delta bitrate saving in % [7]). Table 3 shows the % saving by using MB level adaptive coding over picture level adaptive coding. As seen, for the sequences favoring frame coding [3], such as Mobile and Tempete, MB level adaptive coding provide a significant gain over picture level adaptive coding (18~24% for Mobile and 4~20% for Tempete). For the sequences favoring field coding, such as Canoa and Rugby, picture level adaptive coding has some advantage (-3 % for Canoa and -6~-9% for Rugby).

Table 4 shows the % saving by using MB/picture level adaptive coding over picture level adaptive coding. The performance of MB/picture level adaptive coding is guaranteed over picture level coding.

Table 3. Bit Rate savings (%) by using MB level adaptive coding over picture level adaptive coding

	Canoa	*Rugby*	*Mobile*	*Tempete*	*Coastguard*	*Ice Hockey*
IPPPPPPP…	-2.67	-6.79	18.02	4.24	TBD	1.35
IBBPBBP…	TBD	-9.70	23.87	20.07	TBD	3.27

Table 4. Bit Rate savings (%) by using MB/picture level adaptive coding over picture level adaptive coding

	Canoa	*Rugby*	*Mobile*	*Tempete*	*Coastguard*	*Ice Hockey*
IPPPPPPP…	0.14	0.02	18.02	4.24	TBD	1.35
IBBPBBP…	TBD	0.23	23.87	20.07	TBD	3.27

(TBD: our PCs are still running. More data will be provided later.)

5. Conclusions

[redacted]

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Computer simulations were carried out for the test sequences. Test conditions and picture structures of simulations follow the same as defined in core experiment [2]. The simulation results show that

1. MB level adaptive coding can provide significant improvement over picture level adaptive coding for sequence that favor frame coding.
2. Picture level adaptive coding has some advantage for sequences that favor field coding.
3. MB/picture level adaptive coding provides the best performance (up to about 24% savings in the bit rate).

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3. L. Wang, K. Panusopone, R. Gnadhi, Y. Yu, and A. Luthra, "Adaptive frame/field coding for JVT video coding", JVT-B-071, Geneva, Jan. 2002.
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6. T. Wiegand and G. Sullivan "Working Draft Number 2, Revision 8 (WD-2 rev 8)", 4/23/02.
7. G. Bjontegaard, "Calculation of average PSNR differences between RD-curves", VDCG-M33, Austin, 4/2/01.

[redacted]

What is claimed is:

1. A method of improving adaptive coding comprising performing adaptive coding a MacroBlock (MB) level to provide improvements over picture level adaptive coding for sequence that favor frame coding.

Exhibit M

To

Joint Claim Chart

File History Report

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60/398,161

Macroblock adaptive frame/field coding for interlace sequences

Transaction History

Date	Transaction Description
7/23/2002	Initial Exam Team nn
8/4/2002	IFW Scan & PACR Auto Security Review
8/7/2002	Application Is Now Complete
8/8/2002	Application Dispatched from OIPE
9/1/2003	EXPIRED PROVISIONAL

JC882 U.S. PTO 07/23/02

7-23-02 A/Prov

JC879 U.S. PTO 60/398161 07/23/02

PTO/SB/16 (10-01)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EU2155909751US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
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Ajay	Luthra	San Diego, California U.S A

☐ *Additional inventors are being named on the ______ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

Macroblock Adaptive Frame/Field Coding for Interlace Sequences

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☒ Customer Number 20,480 — *Type Customer Number here* → *Place Customer Number Bar Code Label here*

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 7 ☐ CD(s), Number ____

☐ Drawing(s) *Number of Sheets* ____ ☐ Other (specify) ____

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 18-0013

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U S Government agency and the Government contract number are ______________

Respectfully submitted,

SIGNATURE [signature]

Date July 23, 2002

TYPED or PRINTED NAME Steven L. Nichols

REGISTRATION NO. *(if appropriate)* 40,326

TELEPHONE 801-572-8066

Docket Number: JVT-MBCoding

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

[redacted]

Text for MB-Level Adaptive Frame/Field Coding

Motorola Inc.
Broadband Communications Sector
6450 Sequence Drive
San Diego, CA 92121

1. Adaptive Frame/Field Coding at MB Level

For interlace material, the selection of frame or field coding can be made at MB level. The frame/field selection can be indicated in the bitstream using the UVLC code. The UVLC code of 0 is used for indicating frame super MB while the UVLC code 1 is used to indicate the field super MB.

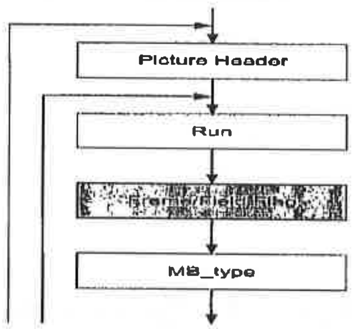

Fig. 1. A frame/field flag of one bit may be required to indicate if the MB is coded in frame or field mode.

2. Possible Block Patterns for Regular MB

A MB of 16x16 can be divided into one of a few possible block patterns of size of 16x16, 16x8, 8x16 or 8x8. For 8x8 mode, a block of 8x8 can be future divided into blocks of sizes of 8x8, 8x4, 4x8 or 4x4.

Fig. 2 indicates how a MB or 8x8 sub-block is partitioned with each block being motion-compensated using a separate motion vector and (for blocks larger or equal to 8x8 samples) using a separate picture reference parameter. If the ABT feature is used, the transform for residual coding is adapted to the partitioning pattern as well (see clause 14).

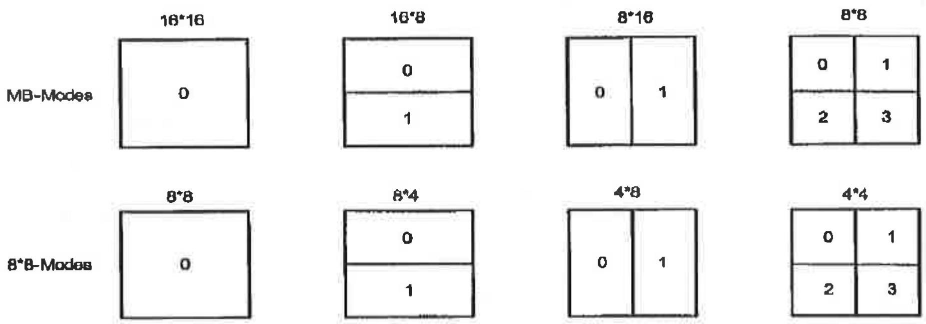

Fig. 2. Possible block patterns for a MB.

Super MB

Input frame is divided into super MBs, each consisting of 2 MBs of 16x16, as shown in Fig. 3. A super MB of 32x16 can be coded in either frame or field mode. For frame coding, a super MB is coded as two frame MBs, and each of two MBs can be further divided into one of few possible block patterns in the same way as shown in Fig. 2. For field coding, a super MB is first split into one top-field MB of 16x16 and one bottom-field MB of 16x16. The top-field, or the bottom-field, MB is further divided into one of few possible block patterns in the same way as shown in Fig. 2.

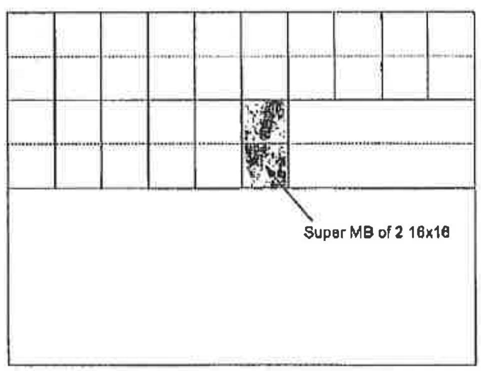

Fig. 3. Input frame is divided into super MB of 2 16x16 pixels.

For frame coding, the top MB of a super MB is coded first, followed by the bottom MB. For field coding, the top-field MB of a super MB is coded first, followed by the bottom-field MB.

For intra prediction, if a block is in field coding, its neighboring pixels in calculating the prediction for the block are the neighboring pixels in the same field parity.

[redacted]

As in frame-based coding, the prediction mode of a 4x4 field-based block is coded based upon the prediction modes of the (above and left) *neighboring* blocks. For interior blocks of a field-based super MB, the neighboring blocks used in coding of intra prediction mode are simply the above and left blocks. For boundary blocks of a field-based super MB, the above or left neighboring block may be in different MB that can be in either frame or field mode. The neighboring blocks for these boundary blocks are defined as follows:

1. If the above or the left MB is also coded in field-based, the neighboring blocks of the boundary blocks in current MB are in the same field of the above or the left MB.
2. If the above or the left MB is coded in frame-based, the neighboring blocks of the boundary blocks in the current MB are on the bottom or the left of the above or the left MB.

Motion compensation for the two MBs (in either frame or field) in a super MB is performed in the same way as described in [1]. Each block of 16x16, 16x8, 8x16, 8x4, 4x8, or 4x4 in a super MB can have its own MV, and each 16x16, 16x8, 8x16, or 8x8 block can have its own reference frame (or field). When a super MB employs field mode, one field MB may refer to any (top or bottom) field of any reference frame in the reference frame buffer.

If in field coding, the skipped MB (copy mode) is reconstructed by copying the co-located MB in the most recently coded I or P field of the same field parity.

The MVs are differentially coded. PMV of the current block follows the same rules described in [1]. Assume block E, as shown in Fig. 4, is inter-coded. The prediction for MV of block E (PMV) is the median of the MVs of the neighboring blocks A, B, C and D, as shown in Fig. 4. Positions of A, B, C, and D follow the same definition as in [1]. Block E can be either frame- or field-based block.

1. If E is in frame-based, the MVs of A, B, C and D used in calculating PMV are also frame-based. If block A, B, C, or D is coded in field-based, the two field-based MVs are averaged and the vertical component of this averaged MV is multiplied by 2.
2. If E is in field-based, the MVs of A, B, C and D used in calculating PMV are also field-based in the same field parity. If A, B, C, or D is frame coded, then the field-based motion vector is obtained by averaging the motion vectors of the same block in top and bottom MB of a super MB and dividing vertical component of the average MV by 2.

For directional segmentation, follow the same conventions as in [1], but the neighboring blocks are in the same field parity.

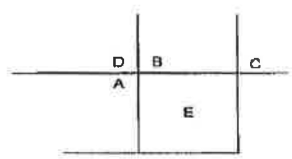

Fig. 4. Calculation of PMV.

PMV of the current block follows the same rules described in [2].

If a macroblock is coded in frame mode and if one or more neighbors of the macroblock are in the field mode, then the reference field number for the field coded macroblocks has to be converted to the reference frame number. The reference frame number of a field MB is obtained by dividing the reference field number of the field coded MBs by 2, unless the reference field number if –1 (intra coded field MBs)

[redacted]

in which case −1 is used for the reference frame number as well. Similarly the reference field number of a frame coded macroblock is obtained by multiplying the reference frame number by 2, unless the reference frame number is −1 in which case −1 is used for the reference field number as well.

One way of implementing the motion vector prediction is as described below. To facilitate the MV prediction of the motion vectors, three motion vector buffers are kept – one buffer for frame MV, another buffer for top field MV and one for bottom field MV. All the three motion vector buffers are updated regardless of whether the MB is coded as a field or frame MB. To clarify the process, let frameMV, top_fieldMV and bottom_fieldMV be the three buffers for storing the motion vectors of the frame/field MBs. Let (mvx_i, mvy_j) be the chosen motion vectors for each block in the top MB of a super MB and (mvx_{i1}, mvy_{j1}) be the motion vectors for the bottom MB of the super MB. Then, the frame and field motion vector buffers are updated as follows

```
if(current super MB  is  coded as frame)
{
        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        frameMV[0][blockx+i][blocky+j] = mvx_i;
                        frameMV[1][blockx+i][blocky+j] = mvy_j;
for(i=0;i<4;i++)
        for(j=0;j<4;j++)
                        frameMV[0][blockx+i][blocky+4+j] = mvx_i1;
                        frameMV[1][blockx+i][blocky+4+j] = mvy_j1;


        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        top_fieldMV[0][blockx+i][blocky/2+j] = (mvx_j + mvx_j1 )/2;
                        top_fieldMV[1][blockx+i][blocky/2+j] = (mvy_j + mvy_j1 )/4;
        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        bottom_fieldMV[0][blockx+i][blocky/2+j] = (mvx_j + mvx_j1 )/2;
                        bottom_fieldMV[1][blockx+i][blocky/2+j] = (mvy_j + mvy_j1 )/4;
}
else
{
        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        top_fieldMV[0][blockx+i][blocky/2+j] = mvx_i;
                        top_fieldMV[1][blockx+i][blocky/2+j] = mvy_j;
        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        bottom_fieldMV[0][blockx+i][blocky/2+j] = mvx_i1;
                        bottom_fieldMV[1][blockx+i][blocky/2+j] = mvy_j1;

        for(i=0;i<4;i++)
                for(j=0;j<4;j++)
                        frameMV[0][blockx+i][blocky+j] =(mvx_j + mvx_j1 )/2;
                        frameMV[1][blockx+i][blocky+j] =(mvx_j + mvx_j1 );

        for(i=0;i<4;i++)
```

```
for(j=0;j<4;j++)
        frameMV[0][blockx+i][blocky+j+4] = (mvx_j + mvx_j1 )/2;
        frameMV[1][blockx+i][blocky+j+4] = (mvx_j + mvx_j1 );

}
```

where blockx and blocky refer to the frame co-ordinates of the first block of the current super MB. Similarly, three buffers are used for storing the reference frame/field information of a macroblock. If the macroblock is coded as frame then its corresponding field reference buffer (top field buffer if the macroblock is top MB otherwise bottom field buffer) is initialized with twice the value of the reference frame number, unless the reference frame number is −1, in which case −1 is used for the reference field number. If the current MB is coded as a field MB then the reference frame number is half the reference field number, unless the reference field number is −1 in which case −1 is used for the reference frame number as well.

If the macroblock is coded as a frame MB then the frame MV buffer is used for motion vector prediction. Also for frame coding the frame reference buffer information is used in motion vector prediction. Similarly, if the macroblock is coded as field MB then field buffers (top field buffers for top field MB and bottom field buffers for bottom field MB) are used in motion vector prediction.

An alternative solution for deriving the field MV from a frame MV is to use the motion vector of the top MB in the super MB for top field motion vectors (with the vertical component divided by 2) and the motion vectors of the bottom MB in the super MB for bottom field motion vectors (again the vertical component of the motion vectors is divided by 2). Similarly the frame motion vectors can be derived from a super MB coded in field mode. In this case, the frame motion vectors of the top MB in the super MB are set equal to the motion vectors of the top field MB and the frame motion vectors of the bottom MB in the super MB are set equal to the bottom field motion vectors (with the vertical component of the frame motion vector in top and bottom MB multiplied by a factor of two).

Intra mode prediction – For prediction of Intra modes, three buffers are maintained for storing the prediction modes of frame and field macroblocks. The frame buffer is used for predicting intra modes of a frame MB, the top field intra prediction mode buffer is used for predicting the intra mode of a top field MB and the bottom field intra prediction mode buffer is used predicting intra modes of a bottom field MB. If a MB is coded in field mode, then the intra mode prediction value of the corresponding frame MB (top MB of a super MB if the current field MB is top field MB and bottom MB of a super MB if the current MB is bottom field MB) is set as the field intra prediction mode value. Similarly if the MB is coded as a frame MB and if the vertical co-ordinate of the macroblock is greater than 1 then the intra mode prediction value for the corresponding field MB is set as the frame intra prediction mode value. If the vertical co-ordinate is less than or equal to 1, intra mode prediction value for the field MB is set to DC_PRED.

The relationships between the field/frame motion vectors, reference frame /field numbers and the field/frame intra prediction modes can be illustrated by the following figures.

[redacted]

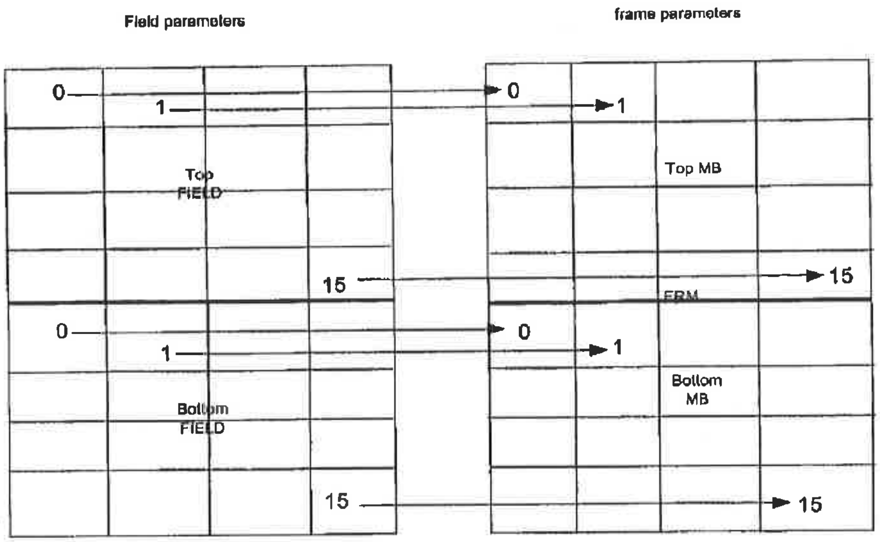

Figure 5. Updating the frame mode parameters if the current Super MB is coded in field mode.

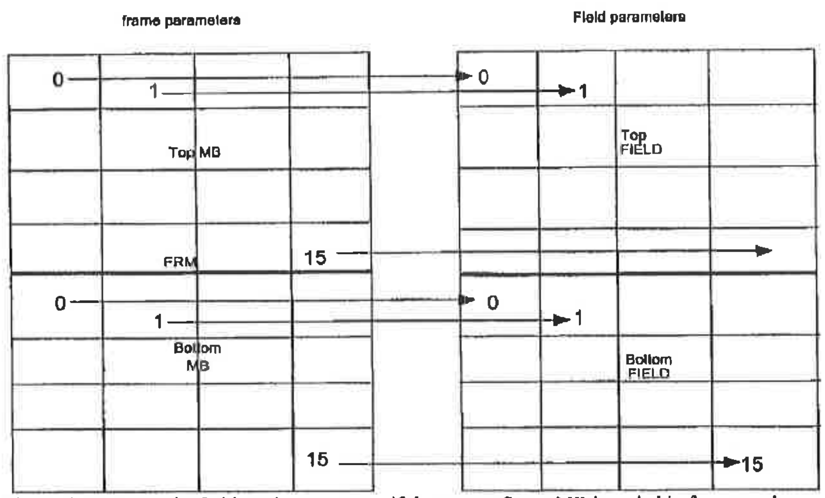

Figure 6. Updating the field mode parameters if the current Super MB is coded in frame mode.

[redacted]

References:

1. T. Wiegand, "JVT CD", JVT-D017, July 2002.

What is claimed is:

1. A method of improving adaptive coding comprising performing adaptive coding a MacroBlock (MB) level to provide improvements over picture level adaptive coding for sequence that favor frame coding.

[redacted]